Sub G1 F2

2433. (amended) The method of claim 2424, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:

heating a selected volume (V) of the coal formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate of the formation (h) is about 10 °C/day.

F3 Sub G1

2435. (amended) The method of claim 2424, wherein allowing the heat to transfer to the part of the formation heats the part of the formation to increase a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

F Sub 4G1

2447. (amended) The method of claim 2424, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

F Sub 5G1

2457. (amended) The method of claim 2424, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

2458. (amended) The method of claim 2424, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

Sub G1 F6

5151. (amended) The method of claim 2424, wherein the heat is allowed to transfer from one or more of the heaters to at least a portion of the part of the formation to establish a pyrolysis zone in the part of the formation.

5152. (amended) The method of claim 2424, wherein the heat is allowed to transfer from one or more of the heaters to at least a portion of the part of the formation to establish a pyrolysis zone proximate to and/or surrounding at least one of the one or more heaters in the part of the formation.

Sub G1 F7

5156. (amended) The method of claim 5154, wherein the heat is allowed to transfer from one or more of the heaters to at least a portion of the part of the formation to establish a pyrolysis zone in the part of the formation.

5157. (amended) The method of claim 5154, wherein the heat is allowed to transfer from one or more of the heaters to at least a portion of the part of the formation to establish a pyrolysis zone proximate to and/or surrounding at least one of the one or more heaters in the part of the formation.

Sub G1 F8

5161. (amended) The method of claim 5154, wherein at least one of the heaters comprises an electrical heater.

5162. (amended) The method of claim 5154, wherein at least one of the heaters comprises a surface burner.

5163. (amended) The method of claim 5154, wherein at least one of the heaters comprises a flameless distributed combustor.

5164. (amended) The method of claim 5154, wherein at least one of the heaters comprises a natural distributed combustor.

5167. (amended) The method of claim 5154, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:

heating a selected volume (V) of the coal formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate of the formation (h) is about 10 °C/day.

5169. (amended) The method of claim 5154, wherein allowing the heat to transfer to the part of the formation heats the part of the formation to increase a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

5181. (amended) The method of claim 5154, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5189. (amended) The method of claim 5154, further comprising:

providing hydrogen (H_2) to the part of the formation to hydrogenate hydrocarbons within the part of the formation; and

heating a portion of the part of the formation with heat from hydrogenation.

5191. (amended) The method of claim 5154, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5192. (amended) The method of claim 5184, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

5198. (amended) The method of claim 5196, wherein the heat is allowed to transfer from one or more of the heaters to at least a portion of the part of the formation to establish a pyrolysis zone in the part of the formation.

5199. (amended) The method of claim 5196, wherein the heat is allowed to transfer from one or more of the heaters to at least a portion of the part of the formation to establish a pyrolysis zone proximate to and/or surrounding at least one of the one or more heaters in the part of the formation.

5201. (amended) The method of claim 5196, wherein at least one of the one or more heaters comprises a natural distributed combustor.

5204. (amended) The method of claim 5196, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

5205. (amended) The method of claim 5196, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:

heating a selected volume (V) of the coal formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein heating rate (h) is about 10 °C/day.

Response

A. Pending Claims

Claims 2424-2426, 2430-2449, 2457, 2458, 2460, 2461, and 5150-5205 are pending in the case. Claims 2430, 2433, 2435, 2447, 2457, 2458, 5151, 5152, 5156, 5157, 5161-5164, 5167, 5169, 5181, 5189, 5191, 5192, 5198, 5199, 5201, 5204, and 5205 have been amended.

B. The Claims Are Not Obvious Over Tsai In View Of Van Meurs Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2424-2426, 2433-2437, 2457, 2458, 2460, 5150-5153, 5154-5163, 5167-5181, 5184-5194, 5196-5200, 5202, 5204, and 5205 under 35 U.S.C. § 103(a) as being unpatentable over Tsai et al. (U.S. Patent No. 4,299,285, hereinafter "Tsai") in view of Van Meurs et al. (U.S. Patent No. 4,866,118, hereinafter "Van Meurs"). Applicant respectfully disagrees with these rejections.

If a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984). Furthermore, if the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 124 USPQ 349 (CCPA 1959). Applicant submits that the combination of Tsai and Van Meurs would render both inventions unsatisfactory for their intended purposes and would change the principle of operation of both inventions.

In the Office Action mailed December 2, 2002, the Examiner states: "With regards to claim 5153, 5158, and 5200; the open wellbore is inherent in the Tsai method (if the well was not open, the air would not flow into the coal as disclosed). Van Meurs, however, states: "In each heat-injecting well, substantially throughout the treatment interval, the well-surrounding face of

the oil shale formation is sealed with a solid material and/or cement which is relatively heat conductive and substantially fluid impermeable. (Van Meurs, col. 4, lines 52-56) Van Meurs also states: "In a preferred embodiment of the present process, the material for sealing the face of the oil shale formation along the borehole of at least one heat-injecting well is a closed bottom casing grouted by cement arranged to fill substantially all of the space between each outermost metallic element present within the interior of the borehole and the adjacent face of the oil shale formation...." Thus, Tsai appears to require an open wellbore, while Van Meurs appears to require a closed wellbore.

Applicant submits that no reasonable expectation of success exists for the combination of Tsai and Van Meurs. Applicant submits, in addition, that Van Meurs explicitly teaches away from Tsai, and Tsai implicitly teaches away from Van Meurs. Applicant respectfully requests removal of the rejections of claims 2424-2426, 2433-2437, 2457, 2458, 2460, 5150-5153, 5154-5163, 5167-5181, 5184-5194, 5196-5200, 5202, 5204, and 5205.

If an independent claim is nonobvious under 35 U.S.C. § 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988). Applicant submits, in addition, that many of the claims dependent on claims 2424, 5154, and 5196 are separately patentable.

The Examiner states:

> With regards to claim 2433, 5167, 5205; Tsai fails to teach a heating rate, but Van Meurs teaches the heating rate less than 10°C/day. It would have been obvious to one of ordinary skill in the art at the time of the invention to have further modified the Tsai method to have a heating rate less than 10°C/day as called for in claims 2433, 5167, 5207; in order to efficiently heat the formation. The Pwr equation is a well known heat transfer law, and thus is inherent."

Applicant's Specification discloses: "In an alternative embodiment, at least a portion of the formation may be heated to a temperature such that at least a portion of the hydrocarbon

containing formation may be converted to coke and/or char. Coke and/or char may be formed at temperatures above about 400 °C and at a high heating rate (e.g., above about 10 °C/day)." (Specification, page 82, lines 11-14) The recited heating rate appears to have criticality and/or unexpected results not taught or suggested by the cited art.

Amended claims 2433, 5167, and 5205 describe a combination of features including: "wherein heating energy/day (*Pwr*) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day." Applicant submits that the combination of Tsai and Van Meurs does not appear to teach or suggest using a desired heating rate to calculate a maximum average heating energy/day to be applied to a selected volume of a formation.

The Examiner states: "With regards to claim 2435 and 5169; the Tsai reference does not teach the thermal conductivity; however, it would have been further obvious to one of ordinary skill in the art at the time of the invention to have practiced the Tsai method in a coal seam having a thermal conductivity of greater than about 0.5W/(m°C) as called for in claim 2435 and 5169; such a formation would be a desirable choice because it would heat more uniformly."

Applicant submits that features of claims 2435 and 5169 including "wherein allowing heat to transfer from one or more of the heaters to the part of the formation heats the part of the formation to increase a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C)" is unexpected based on literature in the art. For example, Applicant's Specification states:

> Certain embodiments described herein will in many instances be able to economically treat formations that were previously believed to be uneconomical. Such treatment will be possible because of the surprising increases in thermal conductivity and thermal diffusivity that can be achieved with such embodiments. These surprising results are illustrated by the fact that prior literature indicated that certain hydrocarbon containing formations, such as coal, exhibited relatively low values for thermal conductivity and thermal diffusivity when heated. For example, in government report No. 8364 by J. M. Singer and R. P. Tye entitled "Thermal, Mechanical, and Physical Properties of

> Selected Bituminous Coals and Cokes," U.S. Department of the Interior, Bureau of Mines (1979), the authors report the thermal conductivity and thermal diffusivity for four bituminous coals. This government report includes graphs of thermal conductivity and diffusivity that show relatively low values up to about 400 °C (e.g., thermal conductivity is about 0.2 W/(m °C) or below, and thermal diffusivity is below about 1.7 x 10^{-3} cm^2/s). This government report states that 'coals and cokes are excellent thermal insulators.'
>
> In contrast, in certain embodiments described herein hydrocarbon containing resources (e.g., coal) may be treated such that the thermal conductivity and thermal diffusivity are significantly higher (e.g., thermal conductivity at or above about 0.5 W/(m °C) and thermal diffusivity at or above 4.1 x 10^{-3} cm^2/s) than would be expected based on previous literature such as government report No. 8364. If treated as described in certain embodiments herein, coal does not act as 'an excellent thermal insulator.' Instead, heat can and does transfer and/or diffuse into the formation at significantly higher (and better) rates than would be expected according to the literature, thereby significantly enhancing economic viability of treating the formation.
> (Specification, page 150, line 18 to page 151, line 10)

Applicant submits that at least the above-quoted features of claims 2435 and 5169 are not obvious.

C. The Claims Are Not Obvious Over Tsai And Van Meurs And Further In View of Elkins Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2431, 5165, and 5203 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs as applied to claims 2424, 5154, and 5196, and further in view of U.S. Patent No. 2,734,579 to Elkins (hereinafter "Elkins"). For at least the reasons cited in Section B, Applicant respectfully disagrees with these rejections. Applicant respectfully requests removal of the rejections of claims 2431, 5165, and 5203.

D. The Claims Are Not Obvious Over Tsai And Van Meurs And Further In View of Salomonsson Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2461 and 5195 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs as applied to claims 2424 and 5154, and further in view

of U.S. Patent No. 2,914,309 to Salomonsson (hereinafter "Salomonsson"). For at least the reasons cited in Section B, Applicant respectfully disagrees with these rejections. Applicant respectfully requests removal of the rejections of claims 2461 and 5195.

E. The Claims Are Not Obvious Over Tsai And Van Meurs And Further In View of Stoddard et al. Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2448, 2449, 5182, and 5183 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs as applied to claim 2424 and 5154 and further in view of U.S. Patent No. 4,463,807 to Stoddard et al. (hereinafter "Stoddard"). For at least the reasons cited in Section B, Applicant respectfully disagrees with these rejections. Applicant respectfully requests removal of the rejections of claims 2448, 2449, 5182, and 5183.

The Examiner states: "It is well known that ammonia is a byproduct of such heating of coal. This is taught by Stoddard. It is readily apparent that the amount of ammonia is dependent on many design factors, including the formation characteristics (hydrocarbon content, etc.). It would have been obvious to one of ordinary skill in the art at the time of the invention to have practiced the Tsai method, as modified, in a formation with characteristics allowing greater than 0.05% of the produced mixture to be ammonia, as called for in claim 2448 and 5182."

Regarding ammonia, Stoddard only appears to state: "A seal against water incursion serves two purposes: water is excluded from the georeactor and the processes underway, and water soluble products of reactions (phenols, ammonia and the like) are excluded from the aquifer." (Stoddard, col. 3, lines 27-32) Stoddard, in combination with Tsai and Van Meurs, does not appear to teach or suggest features of claims 2448 and 5182, including: "wherein the produced mixture comprises ammonia, and wherein greater than about 0.05% by weight of the produced mixture is ammonia." Applicant submits at least the above-quoted features of the claims, in combination with the other features of the claims, do not appear to be taught or suggested by the cited art.